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BASIC BIODYNAMICS

By

Edward J. Kempf

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Wading River, N. Y.

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INTRODUCTION

One of the basic problems of genetics, cytology, and embryology, and therefore of the medical sciences and of psychology and sociology, is the demonstration of the laws of genetic and environmental determination of the development of individual unicellular and multicellular organisms and the evolution of species.

Long after the invention of the microscope and the discovery of cells came the realization in science that cells are the real units of life of organisms. Eventually biologists concluded that orderly cell differentiation in embryonic development is essentially a process of related protoplasmic changes in the organism in reaction to specific intercellular and external environmental conditions. In this early concept, however, only nutritional and reproductive importance was given to the obscure nucleus, since the various types of cells of the organism were supposed to have like nuclei, whereas gross differences in the protoplasm were observable and traceable in reverse order back to the earliest stages of development of the blastula. Haeckel's law that ontogeny recapitulates phylogeny was assumed to be sufficient somehow to account for characteristic steps in the orderly development of organisms. So intense was the conviction of protoplasmic priority that anyone who questioned its validity lost academic respect.

The metaphysical assumption that a directive vital or spiritual force is necessary to account for the organizing processes of life and by such need as indicative of its existence has long pervaded biological philosophy. Such reasoning reached its climax of popular reassurance under the influence of the German experimenter Hans Driesch (1908), when he applied Aristotle's idea of a purposive entelechy to serve as the director of organismic development. Driesch thought he had thereby accounted for the production of two organisms from the first two cells of the zygote when separated, in contrast to their production of symmetrical halves of one organism when not separated. His theory was hailed as a brilliant demonstration of metaphysical determination, but today no biologist whose mind is free of religious bias recognizes the validity of assuming anthropomorphic forms of direction of the physicochemical processes of life. Nowhere today are the teleological mysteries of purpose in the development of organs in preparation for future use brought more sharply into focus than in the long-established assumption that genes "regulate," "control," and "direct" the development of unicellular and multicellular organisms.

Mendel's report in 1865 of successful experimental segregation of individually assorted hereditary determinants of special physical characters through selective crossbreeding of special varieties of peas was, although widely distributed, utterly ignored by protoplasmic-minded biologists and lost to science until rediscovered in 1900, thirty-five years later.

Innumerable repetitions of Mendel's methods and further elaborations of selective crossbreeding of hybrids in many species of bacteria, plants, and animals in collaboration with the modern investigative methods of cytology, embryology, and biochemistry have verified and amplified his laws of heredity. Knowledge of the protein structure of genic units, their chromosomal loci and arrangements, their orderly hereditary transmission, their direct and indirect qualitative and quantitative enzymatic relations to the production of specific cytoplasmic properties, and the differentiation and development of organs in multicellular organisms in reaction to environmental activations has been enormously increased since Mendel's revolutionary discoveries.

Obsessive-minded geneticists long resisted collaboration with cytologists and embryologists wherein precepts of genetic quantitative determination of the development of specific phenotypic characters were challenged by experimental demonstrations of environmental variations of genic effects. Morgan's (1919, 1934) contributions toward harmonizing theory with experimental evidence in these fields improved cooperation. "The relative role of genes and protoplasm,"* he wrote in 1934, "in the early and later development of the characters of the organism is one of the outstanding problems of genetics and embryology.

"The implication in most genetic interpretation," he said critically, "is that all the genes are acting all the time in the same way." This ambiguous concept, he pointed out, fails to explain why cells differentiate in specific ways in the development of the organism and "leaves the embryological problem where it has always been supposed to be, viz., in the protoplasm."

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*In the following discussion cell protoplasm is also termed the cytoplasm. This is consistent with the terminology of cytology and genetics. The fusion of the nucleoplasm with the extranuclear plasm of the cell upon the dissolution of the nuclear membrane in mitosis makes it desirable to include all of the metabolic processes of the cell except that of the hereditary genetic complement under the term "cytoplasm"

As an improvement in genetic theory, Morgan suggested the alternate view that "different batteries of genes come into action as development proceeds." In explanation, he said: "The protoplasm of different parts of the egg is somewhat different and the difference becomes more conspicuous as the cleavage [of cells] proceeds owing to movements of material that take place. From the protoplasm are derived the materials for growth of the chromatin and for the substances manufactured by the genes. The initial difference in the protoplasmic regions may be supposed to affect the activity of the protoplasm, which will start a new series of reciprocal reactions [leading to] the gradual elaboration and differentiation of the various regions of the embryo."

Morgan concluded that his theory that special batteries of genes work in reaction to special protoplasmic conditions was inadequate to explain the orderly regeneration of organs and the anomalies of growth under specific environmental conditions such as the formation of a new lens in the salamander embryo from the edge of the iris after removal of the original lens.

"In this case," Morgan said, "it may seem that if there are special genes whose activity accounts for the maintenance of the pigmented iris cells then there must be a new set of genes that become more active when the lens is removed from contact with the iris. But the result can equally well be accounted for on the basis that all the genes are active, and the organ that is regenerated is primarily determined by the new environment in which the cells of the edge of the iris find themselves. The protoplasm may then be considered different from what it was before, hence with the same output from the genes the end product is different. Of course this inference fails to explain the specific nature of the reaction. This is the real point at issue."

Morgan's inclusion of the intercellular and external environments of the organism as indispensable factors in differentiating the genetic production of protoplasmic properties through the reciprocal protoplasmic regulation of genic action was a great improvement in biological theory. He applied the evidence of experimental cytology and embryology that demonstrated specific adaptations of growth in reaction to specific environmental activations in an enormous variety of plants and animals. The theory of genetic, protoplasmic, and environmental interaction he held, however, as being still too generalized and indefinite to account for graded quantitative differentiations of specific cytoplasmic properties as found in the orderly differentiation and organization of growth of the various tissues of organisms. To explain this quantitative deficiency he suggested:

"It is conceivable that the genes also are building up more and more, or are changing in some way as development proceeds in response to that part of the protoplasm in which they come to lie, and that these changes have a reciprocal influence on the protoplasm....If the latter can change its differentiation in a new environment without losing its fundamental properties, why not the genes also? This question is clearly beyond the range of present evidence, but as a possibility it need not be rejected."

The initial orderly differentiation of special areas in the cytoplasm of the ovum or zygote of some animal species from which the primordial tissues of the gastrula descend and the origin in other species of the primordial tissue cells according to their mechanical positions in the morula, blastula, gastrula, or neurula, from which later organ formations descend, cannot be explained by attributing to the genetic complement, in parts or as a whole, anthropomorphic capacities of discriminative quantitative "regulation."

Morgan's conclusion that differentiated intercellular, intraorganismic, and external environmental actions are indispensable determinants of cytoplasmic and genic interactions has become generally adopted in the biological sciences.

Sinnott, Dunn, and Dobzhansky (1950), in their textbook *The Principles of Genetics,* which fairly presents recent genetic with cytological evidence, hold broadly that "any character is a result of both heredity and environment." Experiment has shown that the organism (phenotype) may develop in a variety of ways under different environmental conditions, although the chromosomal-genic organization (genotype or genome) remains constant in its different cells. Through similarities in effects on the growth of characters of homozygous and heterozygous dominant alleles, two different genotypes will produce apparently similar phenotypes under like environmental conditions. Conversely, under different environmental conditions like genotypes will produce different phenotypes.

"The genotype...is *responsible* for the transformation of materials taken from the environment into an individual which is a more or less faithful copy of its parents....The genotype *directs* the development of the plant or animal and, in its interaction with the environment, produces the phenotype....If the genotype has somewhat different materials to work on the phenotypes may be appreciably different....*What the genotype determines is the reactions, the response, of the organism to the environment.*" (My italics. E.J.K.)

In discussion of the genetics and biochemistry of morphogenesis Needham (1950), like other biologists and biochemists (King, 1956), has applied similar indefinite concepts of genic "regulation" of environmental adaptation as basic biodynamic factors.

Since Morgan presented his concept of genetic, cytoplasmic, and environmental interactive determination of the development of unicellular and multicellular organisms little progress has been made in further improvement of biological theory of how these three sets of factors interact. The enormous amount of new genic, cytoplasmic, embryological, and biochemical evidence has been interpreted as showing that quantitative as well as qualitative differentiations of cytoplasmic properties follow under quantitative variations of genic and/or environmental qualitative determination. In genetics this evidence has been interpreted as showing that a consistent law of genic and environmental interactive determination of the development of organisms and the evolution of species cannot be formulated.

Indefinite generalizations on genic "regulative direction" of environmental adaptations of living cells are certainly incapable of mathematical, hence scientifically lawful, formulation. Herein lurk vestiges of anthropomorphic magic as biological theory attributes to genes of the cell "regulative" quantitative as well as qualitative production of cytoplasmic properties.

The problem of how special batteries of hereditary genes in the chromosomal organization and/or special parts of the cytoplasm become more active and others less active so as to produce, under fitting environmental conditions, the orderly cell differentiation and organic development of organisms characteristic of species is still unsolved. Tracing in reverse sequences of cytoplasmic differentiation in antecedents back to the morula and ovum obviously does not solve the problem.

The genotype of each species is characteristically different from that of any other species. It is, however, somewhat variable in different organisms of a species, in the quality and quantity of genes and their chromosomal arrangements, as limited by viability and reproductivity within environmental adaptability. In order for any genotype to develop an organism characteristic for its species, the embryo must have the supporting activations of limited quantitative ranges of specific environmental energic activations. The viable phenotypes of a species, although varied in the proportions of homologous organs, are always characteristic for the species. Any genotype in too-disequilibrating environmental conditions of any essential nature will develop a malformed, atypical, unreproductive embryo of weak vitality that may be unrecognizable as to species. Any genotype that contains a too-disproportionate quantity of homozygous dominant or recessive genes, or a too-disproportionate dominant genic mutation, or disproportionate chromosomal arrangements of genes will produce, in normal environmental conditions, an organism having abnormal organs and premature lethal consequence.

The interaction of genotypic and environmental determinants on adaptive cytoplasmic differentiation in unicellular and multicellular organisms is so consistent that, when both factors are known, the development of specific characters of the phenotype can be predicted. Obviously, three sets of interactive factors are involved in the determination of development of all forms of unicellular and multicellular plant and animal life; namely, genetic, cytoplasmic, and environmental (intercellular, intraorganismic, and external). All three must be considered as interacting simultaneously and continuously, lawfully, economically, and consistently with the laws of thermodynamics in order to account for the part played by each factor in the development of the unicellular or multicellular organism.

The basic problem is how can hereditary genic factor *A*, which is quantitatively and qualitatively constant and specific, as generally assumed for the genic complements of a series of mitotically reproductive cells, interact with cytoplasmic factor *B*, which is adaptively quantitatively variable in its specific qualities, so as to equilibrate itself with the environmental factor *C*, which is both quantitatively and qualitatively constant in some parts and variable in others in supporting and destructive energies.

Basic Precepts for a Science of Genetic and Environmental Determination of Living Cell Behavior

The constructive and destructive values or effects of the different kinds and quantities of environmental energies for living cells, as independent units, or as interdependent units of an organism, and for the organism as a holistic intercellular organization are based on the highly specific holistic electrodynamic organization and metabolic needs of the cells. We begin, therefore, with the biodynamics of cell metabolism and environmental behavior as now applied in biochemistry.

It is now assumed in the biological as well as the physical sciences that the basic sensorimotor units in the pyramiding levels of atomic, molecular, and protoplasmic holistic electrodynamic organization consist of four-dimensional (space-time) subatomic protons and electrons. The proton has a constant positive electric charge and the electron has a constant negative electric charge equal in quantity and intensity to the positive charge of the proton. The law of sensorimotor interactions of electric units has been formulated as follows. *Electric units (and larger holistic organizations of such units) having like charges interact with mutually repelling forces, and units having opposite charges interact with mutually attracting forces that vary in intensity directly in proportion to the charges and inversely with the square of the intervening distance.*

The inherent electric acquisitive-avoidance sensorimotor interactions of protons and electrons constitute the active factors in all of their pyramiding levels of holistic electrodynamic organization as atomic, molecular, protoplasmic, cellular, organismic, and personal mental systems of internally and externally equilibrating interactions in reaction to environmental actions. Since such bisensorimotor actions and reactions continue characteristically throughout each level of holistic organization, we may logically assume that herein is the natural basis of the dual acquisitive and avoidance, quantitatively and qualitatively specific, self-selective, self-determinative, and adaptive behavior characteristic of living cells and organisms of cells toward their internal metabolic needs and equilibrating and stressing environmental energic conditions.

Little has been learned directly as yet about the internal submicroscopic biochemical genetic and cytoplasmic interactions of living nucleated cell metabolism. However, such evidence has been accumulated indirectly through the experimental analyses of the cell's equilibrating biochemical interactions in reaction to specific environmental activating and nutritional conditions. It shows that the holistic organization of any living cell exists as the product of pyramiding levels of quantitatively qualitatively specialized, complexly interactive, reciprocally counterbalancing, allied, and antagonistic protoplasmic organelles composed of reciprocally interacting molecular organizations of atomic electrodynamic organizations. Such pyramiding holistic interactions of lesser mechanistic parts include those of the organelles, such as nucleoplasm, chromosomes, and genes, enclosed within a nuclear membrane surrounded by a cytoplasm containing mitochondria and other functional structures, all enclosed as a holistically equilibrating interaction system within a semipermeable outer membrane having limited selectivity of molecular substances that pass into and out of the cell.

The elimination in cells and the transplantation between cells of nuclei and chromosomes, mitochondria, and other organelles, and the changes of intercellular environments through the elimination or transplantation of tissues and organs in different stages of embryonic development of multicellular organisms have all shown that the internal parts of the cell are functionally, structurally, positionally, and mechanistically differentiated so as to work reciprocally toward maintaining internal with external electrodynamic equilibration against internal and external causes of disequilibration. Cells that fail to maintain economical equilibration destroy themselves or become destroyed by externally disequilibrating conditions.

The interactions of the same chemical substances *in vitro* and *in vivo* are identical under the same environmental thermal and pressure conditions. Quantitative analyses of cellular intakes of external free energies (heat, light, and mechanical motions) and of nutritionally bonded energies, with correlation of how they are acquired, digested and internally assimilated, worked over, and used by different kinds of cells show, in each case, precise though different economical, spatial, and temporal steps in metabolizing specific quantities of specific kinds of molecular substances. The energy output in work and heat, and in the excretions of water, carbon dioxide, oxygen, and nitrogenous compounds shows that living cells of every kind are highly specialized, holistic, mechanistic, molecular electrodynamic organizations that conform entirely to the laws of thermodynamics, like enclosed, nonliving, reversibly equilibrating electrochemical systems.

A comprehensive correlation of the more recent special correlations of biochemical analyses of specific substances obtained in living tissue slices (Grup and Sobel, 1955; Dalton, 1955) and the juices of macerated living tissues (Baldwin, 1953), and the specific nutritional and reproductive behavior of pure cultures of cells of known tissue origin (Gey, 1954-1955), and of cells of specific genic complements under specific environmental conditions (Schectman and Mishihara, 1955) gives amply indicative information on the specific intracellular organization of highly complex cyclical and reversible, reciprocally interactive, allied, and antagonistic systems of molecular electrochemical mechanisms involved in the basic metabolic processes of living protoplasm.

The protoplasmic constitutions of living cells of bacteria and of unicellular and multicellular plant and animal organisms are now thought to be organized as equivalent physicochemical processes. Biochemists anticipate that a basic cyclic formation of precise metabolic interactions common to all forms of cell life will eventually be discovered (Oparin, 1938; Needham, 1950; Baldwin, 1953).

Anabolism of any kind, even with adequate thermal support, is based on the autogenous catabolic breakdown of special molecules that supply kinetic energy for the construction of new formations of potential energy. Energy used in anabolism must be obtained from catabolic processes, and energy used in catabolism must be obtained from anabolic and external sources. External electric, thermal, photic, mechanical, and chemical energies act by accelerating, equilibrating, or retarding special metabolic processes of special parts of the whole intracellular electrodynamic interaction system. The utilization of nutritional energy in the living cell for work, recuperation, growth, and reproduction is based essentially on catabolic action. As Baldwin (1953) has expressed it: "Energy used in anabolism must be drawn from katabolic processes. No other source is open."

The processes of anabolism and catabolism are concomitantly interactive and reciprocally counterbalancing in the self-determining and adaptive processes of the different living parts of the cell and of the cell as a whole to its intercellular and other environmental energies. In the resting cell they become coequal. In the excited working cell catabolism exceeds anabolism. If the cell is continuously excited by external stimulation, the anabolic reserves become exhausted and its reconstructive viability destroyed. In the recuperating or reproductive cell anabolism exceeds catabolism. When the proportions of special anabolic reproductions become excessive and potentially disequilibrating and disruptive of the enclosing membrane, special catabolic processes under conducive environmental activation seem to initiate the processes of cell division.

Proteins constitute the indispensable basic molecular electrodynamic materials for the protoplasmic organization of all living cells. The nutritional supplies of animal cells are largely obtained through the capacity of plant cells and bacteria to synthesize them. Proteins are large, heavy, highly complex molecular compounds synthesized out of smaller and less complex amino acid molecules. Baldwin (1953) lists twenty different amino acids found in representative varieties of cells. Of these, ten are essential in food since they cannot be formed by animal cells and ten are nonessential in that they can be formed by the cell out of carbohydrates and fats. Animal nutrition is largely dependent upon plant anabolism and the latter is dependent largely upon bacterial anabolism. The variety of proteins that can be compounded by all forms of life in the vast ecological interaction system out of the different kinds of amino acids seems to be limited only by the variety of enzymes that are inherited or acquired by the different species.

Each type of protein molecule has specific atomic composition, mechanical conformation, dynamic sensitivities, and potentiality for releasing electric, photic, thermal, or mechanical energy in specific ways, rates, intensities, and directions in reaction to specific kinds of stimulation (chemical, thermal, photic, and/or mechanical pressure, shock, or stress). Each kind of protein molecule is most economically adapted to carry on a special kind of space-time reaction to special environmental activations and less economically adapted for making other reactions to other conditions. The production of special proteins for special forms of growth and work in organisms to counteract economically special environmental conditions is obviously a vital necessity.

Nutritional reserves in the cell in the form of molecular fats, carbohydrates, amino acids, and salts do not, as such, constitute essential parts of the living protoplasmic equilibrating interaction system; neither are they oxidized in the cell in a manner comparable to burning fuel in a furnace, as has been often suggested in cytology and physiology. In anabolism, as indicated by the behavior of tracer radioactive isotopes (Schoenheimer, 1942), such reserves become worked over into molecular forms suitable for combining with protein compounds that become incorporated into the holistically equilibrating organization of the self-constructive, self-consuming protoplasmic system. In this manner the cell reconstructs itself repetitively in counterbalancing reaction to its repetitive catabolic reductions of anabolic parts, as stimulated by environmental energies. The unfed cell in an otherwise neutral environment catabolizes its nutritional reserves and eventually catabolizes essential parts of its living protein mechanism, with elimination of carbon dioxide, water, and nitrogenous compounds. This process is attended by decrease in the size, weight, and activity of the cell until it loses the cyclical continuity of self-constructive viability.

Chemical interactions *in vitro* that are characteristic of living cell metabolism are, in general, relatively much too slow without sufficient quantities of specific enzymes to accelerate their rates up to that necessary to maintain a living pace. A metabolic reaction that would require minutes, hours, or days to complete itself without the right enzymes is accelerated by a small quantity of such enzymes as fast as the substrates are brought into contact with them (Baldwin, 1953). The mechanism of enzymatic synthesis and splitting of substrates seems to proceed through the substrates' making contacts with the enzyme in a manner remotely comparable to the combining or separating action of a zipper on a parallel series of claws.

Most forms of enzymatic action are now believed to work specifically and reversibly in facilitating the production of states of proportional equilibration between their synthetic and analytic products. Such proportions vary characteristically from equal to disproportionate quantities for different enzymes (Barron, 1949). Increase or decrease in quantity on the synthetic or reductive side of an enzyme's products changes the velocity and direction of enzymatic action toward reducing the higher concentration and increasing the lower side. When relative concentrations are reversed, the direction of the equilibratory process is also reversed until a state of proportional equilibrium is established. The rate of action of an enzyme is proportional to the quantity of the enzyme and to the differences in quantities of the synthetic and reductive products exposed to its action. The process of disequilibration decreases in rate and intensity of steps ($a > b > c$) as proportional equilibrium between synthesis and reduction increases ($A < B < C$).

Enzymatic action varies in rate directly with the temperature, tending to double or triple in velocity with each increase of 10° C. from 0° C., reaching its maximum under 50° C. It is generally sensitive to pressure, shock, light, electricity, and other environmental augmenting or decelerating actions. The rates of action of different enzymes also vary with the degree of acidity or alkalinity of the environing material.

When enzymes are not changed during the course of an equilibrating interaction, the changes in rate and proportions of the synthetic versus the reductive processes are consistent with the laws of thermodynamics

(Barron, 1949; Northrop, 1949; Baldwin, 1953). This form of enclosed equilibrating interaction is consistent with other forms of enclosed equilibrium and may be expressed, consistently with van't Hoff's law, as a law of living and nonliving cellular enclosures: *As any form of energy of the environment that affects an enclosed reversible energic system in equilibrium is changed, the process of equilibration will shift with economy in space and time so that the internal reactions will counterbalance more completely the effects of the external actions.*

Evidently, in nonliving, enclosed, reversible reaction systems enzymes "regulate" the rate of production of the relative proportions of synthetic and reductive products. However, in living cells, as environmentally sensitive, semienclosed, highly complex, qualitatively specific, quantitatively variable, reversibly equilibrating interaction systems, the rate of enzymatic "regulation" is quantitatively adapted to the rates of specific kinds of external activation of cytoplasmic reaction. Here the rate of supply and removal of specific substances to genic and other enzymes is regulated by the circulation of the cytoplasm as it works to counterbalance its catabolic self-consumption and to maintain a state of internal with external equilibration in reaction to specific kinds and quantities of environmental equilibrating and disequilibrating activations.

Enzymes can increase the rate of molecular synthesis or splitting as much as several thousandfold (Oparin, 1938). Since they can generally be used repetitively and indefinitely as rapidly as substrates are supplied and removed, the relative quantities of the different enzymes in a reaction sequence of reversible parts affect the order of productions. The rate of catalytic actions may be accelerated further repetitively in ionic chain reactions in the cell as a whole, such as the excitation and transmission of waves of muscle cell contraction, gland cell secretion, or nerve-cell electric conduction and discharge, by specific kinds of environmental shocking or otherwise imbalancing action.

It may be summarily stated, as a biological generalization, that each species of unicellular organism and each type of cell in a multicellular organism normally contain a limited variety of quantitatively qualitatively specific enzymes and can thereby construct a limited variety of proteins, carbohydrates, and fats out of a limited variety of specific nutritional substances that it assimilates. The construction of specific proteins out of specific amino acids requires that all of the amino acids used shall be presented to a battery of enzymes at approximately the same time. The amino acids that are not more-or-less immediately incorporated into the protoplasmic system of proteins readily undergo deamination. The kind of protein that is formed by a given battery of enzymes seems to depend largely upon the proportions of the specific amino acids presented to them when the anabolic process is active. Mere changes in proportions and sequences of comparatively simple syntheses or in splitting reactions produce tremendous variations in the end products of cellular protoplasm (Oparin, 1938).

It is now generally accepted in biochemistry as being experimentally established that each step in the complex of specifically differentiated, reciprocally interactive processes of anabolism and catabolism of the cell, and hence of the multicellular organism, is dependent upon the reversible actions of batteries of special enzymes. During the processes of cell division most of these enzymes are inherited directly through the orderly reproduction and transmission of thousands of specific genes. Supplementary enzymes are also acquired with nutritional substances. Correlations of the evidence of enzymatic, genetic, and nutritional biochemistry lead to the conclusion that specific hereditary or acquired enzymes must be present in the cell in sufficient quantities in order to facilitate the production of specific cytoplasmic properties at rates and in ratios sufficient to maintain internal equilibration in reaction to the limitations of time and space imposed by changes in any of its environmental energies.

Metabolic Function of Genes

Although the biochemistry of genes and their functions is still largely unknown (Needham, 1950), the evidence of genetics, combined with that of cytology, embryology, and biochemistry, has given many indications of the definitive protein molecular constructions of genes, their positions in chromosomes, their specific enzymatic actions in cell metabolism, the basic part they play in cell differentiation and the development of the organism, and in the evolution of species.

Since the chemical interactions of cell metabolism are much too slow without systems of enzymes to accelerate the rates so as to keep pace with increases and decreases in environmental activations, it is now thought probable that each step in the highly specialized molecular configuration of anabolism and catabolism in each part of the cell is dependent upon the catalytic action of special enzymes.

We may properly surmise that the first cellular units of life were organized around molecular protein enzymes that were probably compounded with graded light-reactive base and acid atomic catalysts. The hereditary transmission of such self-reproductive enzymes, with accumulation and organization in the direction of reproductive survival in reaction to limiting environmental selective activation, directed the evolution of the holistic mechanistic electrodynamic organization of life.

Genes, as individually differentiated hereditary enzymatic units, are generally located in nucleated cells in linear orders in chromosomes as discrete, qualitatively and quantitatively specific, highly complex protein and desoxyribonucleic acid compounds. They have many of the catalytic properties of enzymes, and seem to be related functionally to vitamins and hormones (Sinnott *et al.*, 1950; Needham, 1950; Horowitz, 1950). Genes probably act on substrates either directly, as enzymes, or indirectly through the production of special enzymes.

Genes normally reproduce themselves qualitatively and quantitatively (and positionally, when in chromosomes) out of specific substances as supplied by the extranuclear and nuclear circulation of the cytoplasm. Reproduction of the entire chromosomal-genic complement takes place concomitantly in the metabolic phases preparatory to cell division. Possibly the concomitant interactively equilibrating timing and spacing of the many parts in this complex process limit the quantity of self-reproduction of each gene and chromosome.

Evidence on the hereditary transmission of other genic units in the cytoplasm (termed plasmogenes or plasmons) seems to be well established for some plants and unicellular animals (Caspari, 1948). The enzymatic action of plasmogenes is consistent with that of chromosomal genes. The production of some cytoplasmic properties in some cells seems to be dependent upon the interaction of specific plasmogenes with specific chromosomal genes. Such interactions, like chromosomal genic interactions, are subject to quantitative differentiation by limiting ranges of specific environmental activations of cytoplasmic reactions.

The loss of a gene disrupts the sequence of special enzymatic actions that build up special protein molecules. This is attended by an incapacity to produce a specific cytoplasmic property in reaction to a specific form of external activation, generally with organ-deformative or lethal consequences. A large body of evidence has been accumulated that shows this effect in a variety of genic deficiencies in bacteria and in multicellular plants and animals (Horowitz, 1956). The introduction of a genic mutation is attended by the production of a new cytoplasmic property under conducive environmental activations (Muller, 1956).

Genes, as alleles, tend naturally to vary quantitatively and qualitatively in a series of generations in a large population. As the quantity of a given gene is abnormally increased or decreased relative to the quantities of the other genes, its potentiality for rate of work varies accordingly. Thereby the quantity of changes in its substrates tends to vary disproportionally, under equally disposing environmental conditions, to the ratios of work and products of other genes.

Recent opinions (Dobzhansky, 1955) hold that each gene is normally present once in a haploid set of chromosomes. The economical importance of such distribution is evident in that, in the diploid complement, alleles function in pairs as homozygous dominants, as homozygous recessives or as heterozygous antagonists. Both dominant and recessive genes are now believed to be more-or-less active determinants of cellular development. The effects of the dominant are greater and more easily observable, whereas the effects of the recessive are submerged and often undetectable. Homozygous dominant and homozygous recessive genes often have deformative or lethal effects, whereas heterozygotes for the same alleles produce vigorous hybrids.

Further evidence on the quantitative interaction of genes on substrates is shown in their position effects (Sinnott *et al.*, 1950; Dobzhansky, 1955). Sequences of effects of enzymatic actions on substrates between allies and/or antagonistic genes have been found to be inversely proportional to the distance between their positions in chromosomes. Such quantitative facilitations do not negate interactions between genes in other chromosomes, as is evident in the bisexual differentiation of mammalian and avian species through the accumulation of the same sex genes in one of a pair of chromosomes, with their reduction in its mate and the scattering of the opposite sex genes in the pairs of autosomes. Genetics now holds that hereditary transmission is based not only on the reassortment of genes as independent units, but also on the close arrangement of genes in batteries in chromosomes so as to facilitate economically the quantitative effects of orderly sequences of allied or antagonistic actions on the circulation of substrates.

Since the quantity of each gene is a determinant of its rate of enzymatic action, and since its position in a chromosome in relation to allied or antagonistic genes is also a determinant of the timing and rate of their actions on substrates as supplied and removed by the cytoplasmic circulation, balance in the relative proportions of genes as well as their kinds and positions in the chromosomes are now considered to be major factors in determining the form and growth of cells and organisms and their capacity for environmental adaptation and, consequently, for the evolution of species.

Definite experimental evidence has shown that the quantities of specific genes in a genotype have quantitative as well as qualitative determining effects on the cytoplasmic differentiation and development of special tissues and organs and of organisms as a whole. The genic determinants of excessive, normal, or deficient growth of special organs or parts of special organs have been definitely located, in many cases, in special chromosomes, and relative quantitative differences and spatial relations between the loci have been noted. Differences in size of growth result in haploid, diploid, and polyploid genotypes of the same species. Homozygous dominance in specific genes tends, under equal conditions, to produce excessively disproportionate ratios of specific cytoplasmic properties more rapidly than heterozygous or homozygous recessive genes, hence excessive growth of special cells and organs. Homozygous recessives tend likewise to produce deficiencies. The embryonic consequences of homozygosity are frequently lethal. However, when the actions of the homozygous genes are counterbalanced by the actions of other genes present in adequate quantities and chromosomal positions, specific genotypes may result that produce repetitive characters in phenotypes. This accounts for the production of special organic characters through crossbreeding which, upon repetitive selection, tend to become the characteristics of special breeds. Giant, normal, or dwarf forms of growth of organism and of special organs in similar environmental conditions have been produced thereby. Such growth must not be compared with gigantic or dwarfed growth produced in potential normals by excess or deficiency in some essential nutritional substances or form of stimulation provided by environmental conditions.

The foregoing evidence on proportions of growth of special tissues and organs, as determined by proportions of special cytoplasmic properties, as determined by the relative quantities and positions of special genes in the genotype supports, and does not contradict, the theory that the genes of each genotype determine the qualities of the cytoplasm, and that environmental actions differentiate their quantitative proportions as the cell works to equilibrate itself with the specific energies of its environment. The confusion in interpreting the meaning of the evidence has come from the indiscriminate lumping together of all of the genotypes of a species as if they constituted a single system. We must take each genotype as an individual unity of parts. Then, obviously, what each gene, whatever its quantity, will do with its substrates depends upon the rate of their supply to and removal from it by the cytoplasmic circulation as stimulated by environmental actions and fed by environmental nutritional substances.

Experimental embryology, bacteriology, and mycology have demonstrated that graded quantities of special environmental activations produce quantitative as well as qualitative differences in organisms only when they possess specific genes to facilitate the reaction. Such specificity is accurately demonstrated in the production of antibodies in reaction to antigens. Cells can produce a defensive counterbalancing reaction only when they possess specific genes that facilitate the production of specific proteins out of specific substrates. When such genes are not present, the counterbalancing reaction will not be produced.

The action of antibiotics such as penicillin or streptomycin on bacteria, or poisons such as DDT on insects has remarkably similar consequences, as determined negatively by the lack of certain genes and positively by the presence of mutations. In most instances such chemicals destroy the gene-deficient, defenseless organism. However, a few mutants that happen to possess genes that can produce the specific defensive reaction remain viable and produce a new strain that is resistant to that specific poison. Some experimentally produced strains are nutritionally dependent upon one such special chemical substance and are unable to survive without having it in their food.

The explanation of such specific hereditary adaptations advanced by geneticists (Dobzhansky, 1955) is that they are not the product of accumulation in a series of generations of transmissible acquired cytoplasmic properties, but they are the result of the natural tendency of the enormously complex chromosomal-genic organization of each species to vary in a large number of reproductions in making a small number of mutations of various kinds (pangenesis). Although most mutations are lethal, a few recessives are carried along in each genotype, without deleterious effects as long as they are dominated in heterozygous combinations. Therefore, it may be assumed that a few mutations in a few genotypes in a vast population may *by chance* be chemically fit to produce a protective cytoplasmic property in reaction to a specific kind of physical or chemical stress. Selective crossbreeding of survivals under such conditions tends to evolve genotypes that possess increasing kinds, quantities, and chromosomal arrangements of genes that are adapted to provide special cytoplasmic properties for counterbalancing what was once a form of destructive environmental stress, leading occasionally to the production of varieties of organisms that need to live in such conditions in order to survive.

Environmental Quantitative Differentiation of the Ratios of Genic Qualitative Determination of Specific Cytoplasmic Properties of Organisms

Many geneticists assume that the cells of higher multicellular animal organisms inherit, upon mitotic origin, identical chromosomal complements of genes, although this may involve the reproduction in series of billions of cells of many different types having characteristically different nuclear and chromosomal appearances. Whether or not some genes are quantitatively increased and others decreased or lost in the process of cellular reproduction in tissue differentiation, cytological and embryological evidence amply indicates that all of the genes present in each cell's complement are more or less active in its metabolic life. Therefore all of the different tissues of a multicellular organism are the complex products of quantitative differentiations of like cytoplasmic properties as the result of greater or lesser activities of different components of the hereditary complement of genes, as the result of specific environmental activations of specific cytoplasmic equilibrating reactions. Feeding to organisms different nutritional substances impregnated with the same or different radioactive isotopes has shown that each tissue metabolizes more of special substances and less of others taken from the same circulatory milieu within a given time (Hevesy, 1948).

Embryology has traced the progressive differentiation of organs in many species of multicellular organisms to their origins in early development in organizer zones of the primordial tissue layers, and even to the cytoplasmic zonal differentiation in the ovum. Such information, however, does not explain the process of origin and orderly continuity of the environmentally adaptive cytoplasmic differentiating process in descendant cells as they form tissues and organs.

The process is not entirely explained by the postulate that cytoplasmic differentiation proceeds by genic "regulation" through special genes becoming more active and others less active as the cytoplasm changes in reaction to the actions of special "organizers." The ultimate determinant of development, as in evolution, must be the limiting or selective effect of external environmental actions.

Genes are highly specific hereditary molecular enzymatic units of life. The chemical limitations of their highly specific synthetic and analytic enzymatic actions on specific substrates, and their specific quantitative and qualitative self-reproduction out of specific substrates naturally limit in quantity, as well as quality, the range of environmental physical and chemical energic conditions in which any cell can remain viable; and limit still more the range in which it can be self-reproductive.

The living cell, as a highly complex self-consuming and self-constructive holistic mechanistic electrodynamic organization, catabolically reduces repetitively specific cytoplasmic protein compounds with converted molecular ionic, carbohydrate, and lipoid inclusions with release of special kinds of kinetic energy. In any case, it concomitantly produces special anabolic reconstructions of potential energy in time and in form to keep the whole complex of internally equilibrating processes working to counterbalance the effects of constantly repetitive and endlessly varying environmental actions and self-consuming reactions. In order to carry on, the individual cell and the organism of cells must receive, repetitively, in accord with its genetic inheritance, supporting quantitative ranges of thermal and other environmental activating conditions and specific nutritional supplies. Increases in the rate of catabolic consumption of special cytoplasmic properties such as produce irritability, conductivity, contractility, special secretivity, or stability, follow upon special kinds of activation by special kinds and quantities of physicochemical stimulation.

Each kind of catabolic reduction of a cell must ultimately be rebuilt from special materials assimilated from the cell's environment; conversely, a decrease of catabolism in any direction reduces the need for the assimilation of nutritional substances to be used for rebuilding such anabolic reserves. In unicellular organisms and in interdependent cells of multicellular organisms, slight but repetitive increases in specific environmental activities (intercellular, intraorganismic, and/or external) stimulate counterbalancing increases in the proportions of specific cytoplasmic properties, and inaction in other directions reduces the relative proportions of other properties. Through such selective acquisitive assimilative reactions the ratios of special cytoplasmic properties in cells are adaptively differentiated positionally and quantitatively, as well as qualitatively, as facilitated by the genotype, to counterbalance economically the unavoidable easing and stressing conditions of their environmental energies.

Such holistically self-selective and adaptive metabolic processes in each cell are carried on through the internal circulatory action of its cytoplasm. The internally and externally equilibrating interactions of the different parts of the cytoplasm move specific chemical substances to and from the genes in the nucleus in kind, rate, quantity, and sequence so as to facilitate the anabolism of specific materials that counterbalance the specific catabolic reductions as excited by specific kinds and quantities of environmental activation. As cells differentiate in increasing ratios of specific cytoplasmic properties and reductions of others under repetitive environmental activations, they progressively increase in sensitivity and reactivity to such specific environmental stresses, and decrease in reactivity to equable conditions. Thereby they assimilatively lower their reaction threshold in electrodynamically specific acquisitive ways to specific kinds of physical and/or chemical stimulation and eliminatively raise the threshold to other forms of stimulation.

The different types of cells of the organism having like genic complements have also like cytoplasmic properties, but in specifically differentiated quantitative ratios in counterbalancing reaction to the special ranges of their individual environmental activations. Tissue cells differentiate early in embryonic development in the ratios of like cytoplasmic properties in counterbalancing reaction to the stresses of the special conditions of their mechanistic positions in the organism. Thereby all of the cells of an organism are nutritionally, as well as functionally, reciprocally interdependent. They acquire from and eliminate into the same intercellular circulatory medium (blood in animals, sap in plants) specific substances as needed to counterbalance their individual external stresses and internal metabolic reactions to their intercellular, intraorganismic, and external environmental activations. Thereby the organism of cells differentiates its organs as the cells reproduce and organize their interactions into a progressively developing organism.

Genetic qualitative and environmental quantitative differentiation of cytoplasmic properties necessitates the adoption of a new dynamic concept in biology. Instead of thinking in terms of the motions of parts, as in physiological and biochemical analysis, we must think of the parts of pyramiding levels of holistically organized electric energy, for such is the essential nature of life.

The regulative effects of environmental quantitative differentiation of the ratios of specific genic qualitative determination of cytoplasmic properties, as internally and externally equilibrating processes, is readily demonstrable in cellular mitosis. The two daughter cells of a mitosis presumably inherit identical chromosomal-genic complements and nearly equal ratios of the same cytoplasmic properties. However, where the intercellular, intraorganismic, and external environmental conditions are slightly different for each daughter cell, through each having contacts with other kinds of cells in somewhat organismic different positions, their cytoplasmic ratios differentiate in equilibrating adaptations to their respective environmental physical and chemical activations.

That the basic determinant of the course of mitosis is the ratio of cytoplasmic properties adapting in counterbalancing reaction to environmental activation is evident in the fates of the different tissue cells of the organism. The most highly specialized cells, those of striated muscle and nerve, eventually develop such highly disproportionate irreversible ratios of special cytoplasmic properties that reproductivity eventually becomes normally suppressed. Other specialized cells, such as the cutaneous, hematopoietic, capillary, mucosal, connective, hepatic, and glandular, having many if not all of the same cytoplasmic substances in different, but not too disproportionate, ratios, retain vigorous capacities for reproduction under conducive environmental activations. They react normally with augmentation of growth in size and/or reproduction to irritation and working stress.

The ratio of cytoplasmic properties in conducive environmental activations, and not the genes, is the determinant of mitosis of the different tissue cells of the organism and of the eventual gamete-producing meiosis of the germ cells. Evidence for the environmental part in this regulative process is to be had in the reproductive behavior of every type of cell in the organism. The genic and cytoplasmic interactions in mitosis of the different tissues are characteristically similar, although the cytoplasmic ratios in the series of reproductions tend to differentiate progressively toward irreversibility with each generation of cells as the intercellular and intraorganismic environmental conditions change.

In many primitive hermaphroditic plants the cytoplasmic differentiations of various tissues remain more or less reversible. In many cases, upon transplantation of tissue from an organism of one species to that of another species under conducive environmental conditions, the graft proliferates adaptively to the new conditions in the host and eventually produces gonadal cells with genetic complements characteristic of the donor's species. Eventually some of the descendants differentiate as germ cells and undergo meiosis and produce female or male gametes according to their positions in the gonadal organ.

In genotypically equipotentially bisexual poikilothermic animals (many fishes and amphibians) the germ cells in early embryonic development are migratory and differentiate in male or female direction according to their positions in the medulla or cortex of the gonad. The cortex produces the female hormone, the medulla the male hormone. The greater growth of the cortex over the medulla determines that more of the female hormone is produced than the male hormone, and the bisexual organs of the organism differentiate dominantly in the female direction. When the medulla outgrows the cortex the reverse ratio of sex hormones and growth is produced. The rate of growth of the gonadal cortex is less inhibited by cold than the medulla; therefore, in cold temperatures more young organisms develop female than male organs. In warm temperatures the reverse proportions of growth result.

In genotypically unipotential, bisexual, isothermic animals (mammals and birds) the genetic determination is normally sufficiently dominant in the male (M/f) or female (F/m) direction to determine that the medulla of the gonad will outgrow the cortex and produce male germ cells, gametes, and organs, or that the cortex will dominate and produce female germ cells, gametes, and organs.

The ectodermal tissues of the embryos of triplastic animal organisms, exposed to greater variations of external environmental stimulation, eventually produce the skin, hair, teeth, nails, sensory organs, integrative nervous system, adrenal medulla, the interrelating endocrine pituitary gland, and the oral mucosa. The endodermal tissues, exposed to more constant forms of external nutritional stimulation and respiratory exchange, produce the mucosa and glands of the alimentary system, the liver, and the mucosa of the respiratory system. The mesodermal tissues, exposed directly to intercellular and intraorganismic stimulation, produce the circulatory system and the somatic and autonomic muscular systems, the skeleton, the reproductive system, the adrenal cortex, and the nephritic, metabolic waste-eliminating organs.

Apparently the same environmental conditions have different values and different, though homologous, effects on the phenotypes of different genotypes of the same brood. This is evident in prenatal as well as postnatal development. In the mammalian uterus the embryonic development of the gonads of male and female heterozygous twins is subjected to different effects by the estrogenic-versus-androgenic hormonal ratios of the mother's blood. A continuously strong maternal estrogenic ratio, upon permeating the placental circulation, chemically opposes and retards the development of the gonadal tissue of the male embryo and supports the development of gonadal tissue of the female embryo. A too-strong androgenic ratio has opposite effects, thereby the differentiation in development of the bisexual genital and somatic organs of male or female genotypes may be harmoniously proportionate, retarded, or disproportionate, as determined by apparently like environmental conditions that have actually very different values and effects on different genotypes.

A comparably consistent process exists in unicellular organisms. Clones of descendants of the same parent cell, living together in different positions in a closely limiting environment, tend to differentiate more or less cytoplasmically and to become nutritionally dependent upon each other, probably for special metabolic exchanges, although most of them have, presumably, mitotic reproductions of like genic complements.

Precise evidence of genic and environmental interactive determinations of cytoplasmic differentiation exists in the fate of tissue transplantations in the embryonic development of amphibians. Cells having reversible cytoplasmic ratios develop in equilibrating accord with the new organismic environmental position in the host. However, later tissues, having irreversibly differentiated cytoplasmic ratios, do not adapt to the new position, but continue to reproduce in the same type, resulting in disproportionate growth of accessory organs. In the cross-transplantation of reversible cells between two different species, tissues characteristic for the new position in the host are developed with, however, retention of properties characteristic of the genotype of the donor (Spemann, 1938).

Environmental conditions that, through various forms of repetitive nutrition and/or irritation by radiant, chemical, or mechanical energy, stimulate adaptive differentiations of cytoplasmic ratios that are more-or-less self-reproductive may also account for the development of precancer cells and, eventually, of wildly reproductive cancer or other tumor cells with or without mutation. Mutations occur in mitosis or meiosis, indicating that special ratios of cytoplasmic substrates may be the basis for so-called "spontaneous mutation" or chromosomal aberration during the molecular reproduction of a gene or in the reproduction of a chromosome. The possibility that excess or deficiency of a special substrate relative to the other substrates during the complex phase of simultaneous reproduction of all the genic units and their chromosomal carriers, although indicated by the evidence of biochemistry and cytology, has not been given due consideration by geneticists.

Apparently spontaneous variations in chromosomes in ascitic and other tumor cells and in exfoliative cervical mucosa cells, the chromosomal changes found in gynandromorphs, and the mutations produced by electronic and thermal radiation and chemical interferences all indicate that the chromosomal-genic organization is not as independent of cytoplasmic metabolism as heretofore assumed. Genes as well as chromosomes seem to be qualitatively variable in reaction to some cytoplasmic properties produced in adaptation to special environmental activations. However, abnormal chromosomal-genic variations in mitotic cells do not discredit the assumption, now generally accepted in biology, that normally all mitotic cells of the organism upon origin inherit like chromosomal-genic complements.

Cellular and Organismic Acquisitive-Avoidance Discrimination of the Values of Environmental Conditions

Cells must inherit specific genic enzymes or genic producers of specific enzymes or must acquire specific enzymes that facilitate the production of specific cytoplasmic properties, so as to counterbalance in rate, quantity, quality, position, and form the effects of changes in specific environmental activations. Any cell that is deficient in any essential genic or acquired enzyme develops progressively an unreproductive and, eventually, unviable disproportionate ratio of cytoplasmic properties that work out of time and out of form with its environmental activations.

The highly specific molecular organization of genes, the chemical limitations of their highly specific anabolic, synthetic, and catabolic reductive enzymatic actions on specific substrates, and their quantitatively and qualitatively specific self-reproductions from specific substrates naturally limit the range of environmental physical and chemical energic conditions, quantitatively as well as qualitatively, in which a unicellular or multicellular organism can remain viable, and limit still more the range in which it can be self reproductive.

Each cell, as an independent organism or an an interdependent unit in a multicellular organism is organized, upon its origin, in its genetic system and in its cytoplasmic system, as equilibrating and interacting allied and reciprocally antagonistic organelles composed of allied and reciprocally antagonistic protoplasmic organizations of allied and antagonistic molecular organizations of the atomic organizations of the reciprocally interactive allied and antagonistic basic electric units of nature. This pyramiding electrodynamic organizing process works to acquire and assimilate whatever produces internal with external equilibration and to eliminate and avoid whatever produces such disequilibration. It extends itself in the differentiation and development of the tissues and organs of multicellular plant and animal organisms, evident in the anatomical mechanical arrangements and the physiological and biochemical interactions of the specialized parts of the whole. This organizing process also produces in the animal organism, as the parts integrate as a whole, the state of vegetative, recuperative unconsciousness and of discriminative consciousness of itself interacting selectively, acquisitively and avoidantly, with its environment of equable and stressing actions.

The holistic organization of the equilibrating interactions of bound or enclosed allied and reciprocally antagonistic functional structures is evident in every pyramiding level of the electrodynamic processes of life (atomic, molecular, protoplasmic, cellular, organismic, personal, mental, and social). It is obviously the only mechanistic process that can maintain a continuously adaptive state of internal with external equilibration in reaction to a complex environment of constant and more or less variable and discontinuous or repetitive equilibrating and stressing energies.

The specific genic complements and cytoplasmic properties of each cell and organism naturally differentiate the various chemical and physical energies of its environment into (1) quantitatively equilibrating, supporting, and constructive conditions of nutrition and activation that it must work to acquire and assimilate as needed for anabolic recuperation against self-consuming catabolism, and (2) disequilibrating, antagonistic, and destructive conditions that it must work to avoid, and internal accumulations of by-products of metabolism that it must work to eliminate in order to maintain a continuously adaptive state of internal metabolism in equilibration with the varying energies of its external environment. Thereby the cell and organism, growing as genetically determined toward maturation and reproduction, adapts itself internally to its external environment and adapts its external environment to its internal needs.

The margin of supporting environmental energies of each kind (heat, light, water, gases, acidity, alkalinity, metallic ions, stresses, pressures, and nutritional substances) at any time is limited quantitatively as well as qualitatively for each cell as an individual unit or as an interdependent unit in an organismic unity and for the organism as a whole. Thereby each form of unicellular and multicellular life (bacteria, plants, and animals) is naturally surrounded in every way and direction by endless quantitative variations of specific energies, ranging from supporting equable conditions to opposing, stressing, and destructive excesses or deficiencies.

Naturally, each species can survive and reproduce only within a narrow range of repetitive quantitative variations of qualitatively specific environmental energic conditions. Such equable environmental conditions are involved in every way and direction with more-or-less stressing to destructive quantitative variations for the species, and are far more narrowly limited for the viability and still more for the reproductivity of each individual of a species.

Supporting, work-easing and opposing, stressing and work-increasing environmental conditions are more or less complex and variable in quantity and quality and in contiguity and continuity, and they exist together simultaneously in various forms in most situations and often in the same things. Since stressing and potentially destructive conditions far outnumber and outweigh the constructive conditions, readiness for avoidance reaction generally dominates readiness for acquisitive action.

The complex energies of the organism's environment are differentiated continuously and simultaneously according to its internal genetic and cytoplasmic constitution and metabolic needs into (1) supporting, constructive, work-easing, energy-conserving conditions that excite acquisitive reactions and inhibit avoidance reactions, and into (2) opposing, work-increasing, stressing, and destructive energy-expensive conditions that excite avoidance reactions and inhibit acquisitive reactions. Self-controlling coordinations of sensory with motor and secretory reactions, and of nutritional assimilation with consumption for repair and growth, are maintained through allied functions working acquisitively and reciprocally with antagonistic functions working avoidantly, so that when one reaction system is stimulated excitatorially to increase activity in a particular way, rate, direction, and sequence, its antagonists are stimulated inhibitorially so as to decrease activity and not produce internal conflicting functions. Only in this way can the cell and the organism coordinate motor reaction with sensory reaction to environmental action.

The Basic Laws of Biodynamics

The preceding innovations in the evaluation of the meaning of the pyramiding levels of the holistic electrodynamic organization of all forms of life and the cytoplasmic and genetic quantitative, qualitative equilibrating interactions with environmental actions for adaptive viability and reproductivity make it possible to formulate six basic laws of biodynamics.

The first law is the universal law of holistic electrodynamic organization. *(1) Many parts in one interact economically in space and time as one in many in maintaining internal with external equilibration in reaction to internal and/or external causes of disequilibration.*

Evidence for this law exists at every level of electrodynamic organization (atomic, molecular, ionic crystalline, enzymatic, protoplasmic, cellular, organismic, mental, ecological, and social). The physical as well as the biological sciences must apply this law of the materials of motion and the motions of materials in order to account for the behavior of holistic organization and environmental adaptation of life in any form.

I have been unable to find any recognition of this law in physics, chemistry, or biology, although its processes are obvious in the analysis of wholes into parts and the synthesis of parts into wholes. Since the discovery of primary and secondary organizing centers in embryonic development and the demonstration that graded quantitative effects on special forms of tissue growth develop in reaction to graded quantities of special chemical substances, the search for the mechanism of the orderly regulation of morphogenesis has shifted largely to biochemicals. The answer, I think, lies in the laws of biodynamics.

The second law of holistic biodynamic organization follows from the first. *(2) Unicellular and multicellular living organisms must work so as to acquire and assimilate from the environment specific nutritional and other activating energies, as needed, to maintain internal with external equilibration, to eliminate or counterbalance whatever produces internal disequilibration and to avoid whatever produces external disequilibration.*

This law can be equated mathematically as follows:

$$OA\,\frac{ac + as}{av + el}\quad\underset{\longleftarrow}{\longrightarrow}\quad E\,\frac{su}{op}\quad\underset{\longleftarrow}{\longrightarrow}\quad B\,\frac{ie + ee}{id + ed}$$

Let OA represent the physicochemical state or attitude of the organism, and $ac + as$ its acquisitive-assimilative needs, and $av + el$ its reciprocal avoidance-eliminative needs. Let su represent the supporting, and op the opposing conditions of its environment E to its needs. Let B represent the work and growth behavior toward maintaining a state of internal and external equilibration $ie + ee$, against internal and external causes of disequilibration $id + ed$.

(a) Given quantitatively the known physicochemical states and acquisitive and avoidance needs for metabolic equilibration of a cell or of an organism of cells, and the environment of energic conditions supporting and opposing its needs, we can predict its work and growth behavior quantitatively as well as qualitatively in space and time.

(b) Given the quantitative-qualitative metabolic status and the acquisitive and avoidance behavior of the cell or organism, we can calculate both quantitatively and qualitatively its environmental determinative equilibratory and stressing conditions.

(c) Given the adaptive course of behavior and the environmental conditions, we can calculate the preceding metabolic status and attitude of the organism.

These three methods, observation, analysis, and reasoning, by which man can understand the behavior of himself and other living and nonliving things in reaction to environmental actions, are applied by people in everyday life and in all of the sciences. The application of one or two of these methods, with avoidance or neglect of the third method for rechecking and correcting evidence and interpretations of meanings, results in incomplete scientific understanding of all the processes involved in the holistic organization of interactive internal and external parts. All three methods must be applied realistically.

Method *a* is applied chiefly in the experimental physical and biological sciences. Method *b* is applied chiefly in medical diagnosis and therapy. Method *c* is applied chiefly in the detection of motives and attitudes, particularly in law and in the estimation of intelligence and sanity versus insanity. Obviously all three methods must be applied in science as well as in everyday life in order to understand *how* things work, in order to know relatively *what* they are and *why* they behave as they do.

To illustrate: in the culture of bacteria or of any young plant or animal in a given controlled environment of quantitatively favorable thermal, photic, mechanical, nutritional, and other necessary supporting conditions that includes also a stressing excess or deficiency in some one essential factor, both cell and organism will work to counterbalance the stress and to develop adaptive forms of growth. In specific nutritional deficiency of any kind due to environmental deprivation, chemical substitutions from available material will be selected to produce as nearly as possible an equilibrating nutritional state and compensatory growth, as in the quantitative qualitative nutritional selection of plants and animals (Richter, 1942-43). In excessive environmental stresses and other destructive conditions defensive equilibratory behavior develops toward counterbalancing the effects of the stress.

The third law, as the law of pathological biodynamics, follows from the second. *(3) When an organism is continuously or repetitively forced in an unavoidable situation to accept what it needs to avoid, or is forced to avoid what it needs to acquire, it immediately develops pathological functional changes followed by pathological organic changes.*

If, in embryonic development, any one of the life-essential properties of the environment is made too excessive or deficient to be equilibrated compensatorially, growth tends to become so deformed and so disorganized that a monster of low viability is produced that may be unrecognizable for species (Child, 1941). No hereditary genic complement can produce normal cells, or an organism of cells, without fitting environmental supporting nutritional and stimulating conditions to equilibrate their metabolic needs as they develop.

Progressive pathological disequilibration terminates eventually in the destruction of the organism. The vast implications of the laws of biodynamic equilibration for health and disease in prenatal and postnatal development can be demonstrated readily in any form of life.

The fourth law of biodynamics of genetic and environmental determination follows naturally from the first three as the result of the fact that unicellular and multicellular organisms are compelled by self-consuming metabolism to work to maintain a state of internal with external equilibration against internal and environmental causes of disequilibration. *(4) The hereditary genotype determines the production of the specific metabolic properties of the cytoplasm out of specific substrates, and environmental conditions differentiate the quantitative ratios of these properties.*

The validity of this law has been demonstrated by an analytical reconsideration of well-established experimental evidence on the genic and environmental determinations of cytoplasmic differentiation. An equivocal interpretation now prevalent in biology is that, since both genes and environment have qualitative and quantitative determinative actions on adaptable cellular differentiation, a biological law governing their interactions cannot be deduced from present evidence to account for the orderly holistic development and overt behavior of unicellular and multicellular organisms. This interpretation has been disproved in the preceding considerations of experimental evidence.

The fifth law, or law of four-dimensional economy of biodynamics, follows from the preceding laws. *(5) Living unicellular and multicellular organisms work and grow toward maintaining maximal internal with external equilibration with minimal uses of energy in space and time.*

When internal disequilibration follows in reaction to an internal or an external stressing action in living, enclosed, reversible equilibrating interaction systems, the reaction moves toward acquiring and assimilating whatever restores internal with external equilibration and moves concomitantly toward avoiding and eliminating whatever causes disequilibration. The re-equilibration moves with progressive steps of decreasing quantity and intensity ($a>b>c$) of disequilibration toward increasing space-time economy ($A<B<C$) in the equilibrating interactions of the parts so as to maintain the integrity of the holistic organization.

Environmental energies that affect the course of work-and-growth development of life differentiate naturally into the constant, the repetitive cyclical, the repetitive variable, and the irregularly variable. The gravity of the earth is constant in force and direction. The gravities and combined tidal effects of the sun and moon and their thermal and photic radiation vary in repetitive annual, seasonal, and diurnal cycles of intensity and direction. These repetitive effects, however, are varied more or less irregularly by changes in atmospheric pressure, moisture, and currents of air and water. Most of the topographical conditions of the earth are fairly constant as habitats during the life of an organism, but vary during the life of its species. Most of the supporting environmental conditions in the form of equable degrees of heat, light, moisture, salinity, food, and safety, and the stressing conditions in the form of excesses and deficiencies in these essentials and in competitors and predators are irregularly variable. The self-consuming, self-reconstructive organism must necessarily be able to adapt itself and work so as to acquire externally, assimilate internally, and avoid externally and eliminate internally whatever produces stress so as to maintain maximal space-time efficiency with minimal uses of energy.

Since most variations in environmental energies tend to repeat, conditioned functional states that are more economically ready to repeat the counterbalancing reaction tend progressively to become established. Thereby the present state of an organism is an outgrowth of the past, with preparation for the future.

Better-prepared functions in organisms tend to eliminate the less efficient ones, and better-prepared organisms tend to eliminate their weaker competitors regardless of species. Each step in development of the individual or in the evolution of its species tends, through preponderance of reproduction of more economical mechanisms, to become a step toward greater efficiency in the extension in time and space of its controllable environment as the means of maintaining self-control of equilibration against causes of disequilibration.

The importance of this law of biodynamics for environmental adaptation in every form of life is evident in that economy in use of energy reduces work for capturing energy and increases the proportion of energy available for reproduction. Under the selective action of more-or-less rapid intensive and extensive changes of the different environmental energies and the universal competition between organisms for living space and food, survival with reproduction depends upon developing maximal efficiency with minimal use of energy in the work and growth of cells, organs, and organism.

The sixth law, or law of evolutionary differentiation of holistic biodynamic organizations, follows as a logical consequence of the fifth law. *(6) The more energy must be used in work for survival, the less energy is available for reproduction. Conversely, as less energy must be used in work, the capacity for reproduction increases.*

One hundred years have passed since Charles Darwin and A. R. Wallace proposed, contemporaneously but independently, similar theories of the common origin and differentiating evolution of species as the result of the natural selection of organisms more fit to reproduce their kinds through the elimination of the unfit under limiting environmental conditions. This process, both men suggested, results in repetitive circular selections of hereditary determinants of the development of advantageous organs for work under special environmental conditions.

Biology now accepts the fact that the natural selection of phenotypes better fitted to reproduce under limiting conditions, as in man's selective breeding of plants and animals, tends automatically to select genotypes from natural pangenic variability that are more fit to produce such phenotypes.

The fifth and sixth laws of biodynamics account for the natural origin, in the accumulative pressure of potential energy inherent in all forms of life, of the drive, heretofore unexplained in biological theory, toward progressive or regressive evolution of more efficient phenotypes and, consequently, toward reproduction of more effective genotypes to work and reproduce under the selective effects of limiting environmental conditions.

The evolution of related species descended from a common ancestor tends naturally to diverge in a long series of generations through survival and reproduction of organisms mechanistically equipped to function with progressive efficiency in increasingly different limiting environmental conditions. This is evident in the behavior of life as one great ecological system including many interactive and interdependent plants, animals, and bacteria bound to live together in a limited area and forced to keep pace with climatic changes of heat, light, moisture, and salinity, and to cooperate and compete with each other for nutritional supplies and living space.

Species that have achieved maximal efficiency for reproduction under the selective action of severely limiting but nearly constant environmental conditions tend to vary less in genotypes because of the elimination of ineffective mutations and chromosomal aberrations. However, species living in more extensively equable conditions tend, through survival of more varied phenotypes, to reproduce with greater variation of genotypes. When such equable environments change and become severely limiting through long-term cyclical increases or decreases in different qualities (heat, light, moisture), the weaker intermediary crossbreeds become exterminated, and small populations of hardy hybrids become isolated, resulting eventually in the origin of new and genetically incompatible species. This process accounts for the accumulation of many fossils of closely related species in some areas and few fossils of distantly related species in other areas.

The evidence of paleontology shows progressive evolution in many forms of life from simple to more complex mechanisms toward greater extension in space and time of the capacity for self-equilibration against variations in environmental energies, particularly of heat, light, water, and salinity. Such improvements in the projective use of energy are attended by reduction in the number of reproductions per set of parents, with increase in the chances of survival of young and expansion in the geographical distribution of species. Concomitantly, the regressive evolution toward more simple mechanistic forms, as in parasites, is generally attended by increased capacity for reproduction in a more constantly favorable though restricting environment, as within or on the bodies of hosts. The regressive evolution of useless organs and progressive evolution of useful organs is universally evident under natural selection. Evolution in any direction, like the development of organisms, is the result of the economical acquisition of more efficient functions and organs concomitantly with the elimination of less efficient functions and organs.

The evolution of more controllable, adaptable bisexual differentiation in higher animals from the primal hermaphroditism of lower forms shows that economical improvement in genotypes through the selection of quality and quantity of genes and of chromosomes and the positions of genes in chromosomes attends environmental selection of phenotypes that are physically and chemically more fit to maintain efficient working capacity consistent with more efficient reproductive capacity. Comparative anatomy shows that, as isothermal vertebrates evolved from poikilothermals, the complexity and efficiency of nervous and glandular regulation of working organs increased to counterbalance the environmental changes of heat and moisture more extensively in time and space. Reproductive organs evolved concomitantly from external fertilization and incubation to internal fertilization and external incubation (oviparity) to internal fertilization and incubation (ovoviviparity to viviparity), culminating in the placental mammals. Evolution toward increasing parental support of prenatal and postnatal development has been attended by quantitative reduction of offspring per individual parents.

The different species of bacteria, plants, and animals are physically and chemically highly specialized, but nutritionally interdependent. Therefore, probably all forms of life existing at any period of time in the same geographical limitations have evolved together, although at different rates under different environmental values for different genetically determined needs. They constitute a vast, geographically enclosed, concomitantly evolving, ecological circular interaction system that exists in adaptive equilibration with the evolution of the various environmental energies of the earth and the solar system.

Psychology of the Laws of Biodynamics

The preceding correlations and evaluations of established experimental evidence of the physical and biological sciences have shown that all forms of life have evolved as pyramiding levels of holistic electrodynamic organization (atomic, molecular, protoplasmic, and cellular) under naturally repetitive processes that have been formulated as laws of biodynamics. Basically, many parts bound together in one force each other to interact as one in many in economically (space-time) equilibrating reactions to external actions. Through the enzymatic action of hereditary genetic determination of the production of specific dynamic protoplasmic properties of cells and the environmental energic differentiation of the quantitatively equilibrating ratios of these properties, unicellular organisms become adaptively differentiated to reproduce under different limiting environmental conditions. This repetitive holistically organizing process has extended itself in the evolution and in the development of economically efficient multicellular plant and animal organisms under the conducive actions of supporting ecological and climatic environmental conditions.

The same lawful processes of holistic electrodynamic organization that regulate the orderly differentiation and development of the organs of the individual multicellular organism also regulate in the animal the orderly integration and development of its personal mind. Since these organizing processes in man and other mammals have been presented in previous publications (Kempf, 1918, 1935, 1949, 1953), it is unnecessary to repeat them here. It is sufficient to say that it has been shown how the circular sensorimotor, neuromuscular, and neuroglandular, autonomic-emotivating and somatic-kinesthetizing reflex systems of the organism, working simultaneously as equilibrating interactive allies and reciprocally opposed antagonists, counterbalance the imbalancing actions of their internal and external energic conditions. Thereby they economically organize their integrations in a pyramiding series of converging levels as a holistic, self-righting, self-determining, environmentally selecting and adapting electrodynamic mechanism.

Through the means of the spinal-medullary segmental and intersegmental levels of integration, the neuromuscular and neuroglandular parts organize their equilibratory interactions to form the vegetative unconscious holistic mechanism. Through the diencephalic suprasegmental level, they integrate their interactions into a holistic metabolic thermal-equilibrating mechanism and an antigravity, posture self-righting, subconscious external sensory reactive mechanism that is, however, not conditionable in the primates. Through the cerebral cortical level the subconscious organization integrates its interactions into a holistically organized electrodynamic, internally and externally generally equilibrating, cosensory state producing continuity of consciousness of itself working discriminatively with the supporting and opposing forces of its environment. Hereby it becomes a sensory conditionable personally self-preserving, self-determining, autonomic-emotivating, somatic-kinesthetizing attitudinal organization within the organism that works to preserve the integrity of itself and its organism as it reacts to conditioning external stimulation. Concomitantly it develops organized internal and external sensory associations into perceptive acquisitive and avoidance discriminations of the supporting and opposing conditions of its environment. Through this means it continuously equilibrates its metabolic cravings, emotions, and drives to its environmental conditions and such external conditions with its internal needs.

The evidence that specific biochemical and other physiological processes produce quantitatively and qualitatively specific mental reactions and that such mental processes produce such physiological effects indicates sufficiently that so-called mental processes are specialized forms of holistically organized electrochemical processes. Modern psychology is, at long last, adopting this point of view and abandoning the ancient dualistic mythology that mental processes are supernatural and coordinated with bodily processes. Psychology is thereby developing as an analytic science, but it must apply the laws of biodynamics in order to correlate its evidence and postulates consistently with the sciences of biology, physics, chemistry, and cosmology.

It must be borne in mind constantly that the growth and work behavior, including mental, of each form of life must adapt economically, as genetically determined, to a small range of quantitative variations of specific environmental energic conditions that are fit to support the metabolic processes of the organism. These processes excite acquisitive reactions as the organism requires such things as food, shelter, a mate, safety, and stability. Concomitantly the vastly greater range of actually and potentially more-or-less excessive or deficient, stressing and destructive conditions compels the organism to work and to grow so as to be ready to make defensive avoidance reactions attended by compensatory work to acquire safely equilibrating conditions. Highly specific genetic determination in each species, and more so in each individual of a species, specializes its range of metabolic needs and acquisitive behavior and generalizes its avoidance needs and behavior.

Equably supporting conditions that reduce and ease the work necessary to live and opposing conditions that stress and increase the work necessary to live exist simultaneously, more-or-less complexly and variably in quantity and quality and in contiguity and continuity in all situations and often in the same things and the persons of its social group; therefore the mind can continue to function discriminatively and economically only insofar as it is organized as a dual system of reciprocally interactive acquisitive-versus-avoidance sensorimotor functions in each level of electrodynamic integration.

Since the essential process of mental organization is the same as that of organismic organization, it must be accepted as the basic principle of psychology and psychiatry as well as of other fields of biology. In order to maintain continuity of holistic organization of self-determinative and adaptive functioning in reaction to endlessly variable internal and external actions, conditions that excite acquisitive reactions must inhibit avoidance reactions, and conditions that excite avoidance reactions must inhibit acquisitive reactions. Only thereby can the personally self-determining, consciously organizing mental processes of the organism (now often called the ego-organization) make simultaneously acquisitive and avoidance discriminatory sensory selections and motor coordinations between simultaneously stimulating allied supporting, work-easing conditions and opposing, work-increasing internal and/or external conditions without internal functional conflict and external confusion.

All prenatal and postnatal conditioning of reflexes and higher forms of learning differentiate as reciprocally integrative acquisitive or avoidance reactions. At birth the animal organism has developed, in preparation for its future work with its postnatal environment, specific organs, nervous centers, and more-or-less integratively organized equilibrating interaction patterns of its organs. They are naturally preconditioned to react acquisitively to specific equilibrating contact stimuli (including olfactory and gustatory chemical) and avoidantly to stressing stimuli. Postnatally acquired visual, auditory, olfactory, and contact learning of the different values of environmental stimulation are either acquisitive or avoidance in type as determined by simultaneous associations with prenatally conditioned acquisitive or avoidance excitatory and inhibitory contact stimuli of equilibrating reactions. The ultimate values and effects of learned conditioning stimuli are determined by the metabolic needs and the holistic, self-determinative, emotivated attitude of the organism. The special form of cortical integrations being maintained at the time by the self-determinative attitudinal organization, and not the organism as such, as Pavlov (1928, 1941) and his school have maintained consistently, is conditioned by postnatal environmental experiences.

Lack of repetition of almost any kind of acquired conditioning stimulation of a specific reaction with its inborn predetermined stimuli leads normally to atrophic degeneration of synaptic connections between the association neurons of the reaction. This results in the release of the self-determinative attitude of the organism from repeating useless reactions and habits. Environmental conditions that are indispensably useful to a special form of self-determining attitude of the organism (such as hunger or eroticism) may be useless to other attitudes and states such as satiety, fatigue, sleepiness, fright, or rage.

The metabolic drive of the organism, and therefore of its mental self-determination, is produced by quantitatively qualitatively specific intracellular catabolic actions that produce specific anabolic deficiencies. These, in turn, produce specific deficiencies in the blood, which then excite specific appetitive nervous cravings and acquisitive autonomic-emotivating reinforcements and somatic-kinesthetic, environmentally self-projective attitude formation so as to facilitate work to acquire whatever relieves the need. Upon anabolic sufficiency, avoidance reaction to the same environmental conditions is excited and acquisitive reaction is inhibited.

Acquisitive action toward desired objectives in habitually safe conditioned situations is concomitantly attended by general reciprocal inhibition of avoidance reactions. However, slight new changes in the external situation excitatorially increase defensive avoidance reactions and inhibitorially reduce aggressive acquisitive reactions. This is followed by counterbalancing acquisitive actions to find a safer, more easily controlled situation.

Since living organisms feed upon other forms of life, the struggle is obviously universal to get sufficient food and restful living space and to compete for mates and to reproduce, as emotivated, without being destroyed. The dangers of being destroyed, injured, frustrated, or subjugated far exceed the highly limited conditions of safety. Since most young organisms in wild life are destroyed by other species for food, survivors able eventually to reproduce have generally a more highly organized capacity for making simultaneously both acquisitive and avoidance discriminations and aggressive or defensive reactions. Failure to make effective self-righting discriminations of what to do versus what not to do, in time and place, as changes in supporting and opposing conditions force a decision, produces unreciprocal conflict of autonomic reflexes and of somatic reflexes with disintegrative confusion and painful anxiety attended by apprehension of helplessness, ending in failure and injury or destruction.

The integrative organization of the lower circular reflex levels into a pleasurably self-centered egoistic organization becomes a specialized holistic system within the organismic system as it learns to control itself in reaction to its acquisitive and avoidance autonomic cravings and in reaction to specific social demands, approvals, and prohibitions. The self-determining, self-loving, self-expressive, speaking ego can coordinate economically, in time and space and in quantity and quality, allied forms of internally and externally stimulated sensations into consistent perceptions and ideas, and can think and say what it wishes and wills to do only so long as it can inhibit conflicting conditioned associations that would confuse its sensations, perceptions, and motor coordinations.

Such egoistic organization is observable in the domestication of higher animals as well as in young children. As the human personality develops under a conditioning social system of demands and approvals of what to do and what not to do, to say and not to say, and to believe and not to believe, with responsibility and rewards for accepting the code and punishment for violating it, the egoistic organization develops more or less the capacity of repressing from consciousness socially prohibited ideationally conditioned emotivations. The repressed reactions continue, however, as stimulated in the form of repetitive postural tensions in the organs that produce the craving and that would force the commission of the prohibited actions. The effective repression of a special form of prohibited emotivation requires the development of a special form of socially adjusted egoistic attitude that works to acquire certain kinds of approvals from certain persons and avoid incurring their disapprovals. In the process of cultivating the socially conditioned conformation of the egoistic attitude exists the basis for more normal and practical development and the basis of its neurotic conflicts.

In every neurosis and psychosis we find an incapacity to make reciprocally acquisitive-versus-avoidance discriminations of what is "good" and "right" to do versus what is "evil" and "wrong" and not to do in socially obligatory or otherwise unavoidable family, business, educational, or other situations. The cultural conditioning of the egoistic attitudes and needs of each person in the group proceeds from infancy throughout life on the plan of giving and getting sympathetic approval, praise, and/or economic reward for what is done satisfactorily: versus giving and getting antipathic disapproval, condemnation, and punishment, involving the loss of love and esteem, for what is done wrong. Conflicting imperatives, morals, and demands by the same parent, teacher, employer, or other authority, or between such impressive authorities, are the most common causes of mental confusion and loss of self-reliance and the formation of the compensatory compulsions that are characteristic of neuroses, including psychoses. Submission to conflicting imperatives breaks down the development of the self-determining integrity of the mind and causes loss of consistency in discrimination of what it wishes and wills to do and not to do.

Psychology, psychiatry, and other medical sciences have long held, with genetics, that when states of nervous disintegration and confusion develop in some people and not in others under apparently the same stressing environmental conditions, this is evidence that the more easily distressed and disintegrative individuals have an inherent genetic weakness that does not exist in the more adaptable. This assumption is correct in many cases in any species, but it is erroneous to assume that the same environmental conditions have the same values and conditioning effects on the different genotypes of the offspring of the same parents.

Phenotypes vary in the capacity of the nervous system and of other organs to adapt to the general run of environmental stresses. Human and other animals vary in constitutional type, including the well-balanced, tough and hardy, generally the most adaptable; the excitable hyperkinetic, better adapted to rapidly changing situations; the phlegmatic hypokinetic, better adapted to slowly changing situations; and the weak hyperinhibitory, the most easily confused type (Pavlov, 1928; Kempf, 1941). However, it is completely fallacious, misleading, and obstructing to the medical, psychological, and other social sciences to assume that nervous disintegration and distress in reaction to environmental stress are always based on some genetic weakness. The strongest genotype will not produce a normal organic phenotype when it is forced for too long a period to avoid what it must acquire or is forced to accept what it must avoid. Under such conditions it will first develop pathological functions and, eventually, an organic pathology.

The strongest person, like his domestic animals, will become disintegratively confused in his self-determinative functioning and will grow progressively neurotic when he is repetitively forced, in unavoidable situations, to make acquisitive-versus-avoidance discriminative decisions beyond his capacity to think of what to do and what not to do in a limited time, with the certainty of fearful punishment and possibly endless condemnation or death in case of failure (Kempf, 1953). Psychiatric analysis has demonstrated that the neuroses of man, as of his domestic animals, are produced by repetitive subjection to irreconcilably conflicting demands in unavoidable situations.

Sociology of the Laws of Biodynamics

The laws of biodynamics provide the social sciences with the means of understanding the natural sources of the equilibrating and disequilibrating interactions that develop inevitably between individual human or other animals when bound to live together in social groups under more-or-less severely limiting and restricting environmental conditions. The limitations of space prevent giving here an extensive illustration of the application of the laws of biodynamics in sociology. This will be done more fully elsewhere in an analysis of the systems of social conditioning and group organization as developed in primitive illiterate and literate ancient and modern peoples. It is sufficient here to point out that all forms of social organization, primitive or civilized, gangster or democratic, religious, political, military, fraternal, familial, economic, scholastic, ethical, or criminal can be maintained successfully only so long as and to the degree that the established demands, rules, mores, or laws of what the group must do and what the individuals of the group must do are sufficiently definite and consistent to work reciprocally with what they must not do. Social order and peace, consistency, efficiency, and economy in cooperation between individuals can be maintained only so long as cooperative needs and interests dominate over competitive needs and interests and inhibit antagonistic compulsions.

Summary

It is illogical to assume for the unicellular or multicellular organism having, normally, a specifically limited chromosomal-genic complement and relatively limited environmental adaptability, what is true for the species having greater variations within the characteristic chromosomal-genic system and greater environmental adaptability. It is also illogical to assume that the same environmental conditions have the same constructive or destructive effects on the different genotypes of a species, brood, or litter.

Morgan's theory that specific batteries of genes become more active and others less active in reaction to different kinds of protoplasm seems to be correct insofar as it goes, but it is not sufficient to account entirely for the lawful process of environmental adaptation in individual organismic development. It is indispensable for the cell and the multicellular organism to function repetitively so as to maintain internal with environmental equilibration against the repetitive causes of internal and external disequilibration. Such adaptation is not produced by the prescient "regulative" protoplasmic action of special genes functioning as individual chemical units, as groups, or as a complete system of units.

Since each kind of gene acts directly or indirectly as a specific enzyme on specific substrates, each cell has the hereditary capacity to produce specific cytoplasmic properties only wherein it has specific hereditary genes. When such a cell is exposed to a repetitive unbalancing environmental action that it cannot avoid, its cytoplasmic reaction tends to become disintegrative unless it acquires enzymes that are adequate in kind and quantity to produce, in time and in form, the kind of cytoplasmic responses that will counterbalance the environmental action.

In each independent cell and in the organism of interdependent cells, the genotype – not the environment – produces the specific properties of the protoplasm of the cell, and environmental actions – not the genotype – differentiate the quantities and ratios of these properties as the cell works to counterbalance their effects.

In no other way can the cell or organism adapt itself physically and mentally to the endless quantitative variations of its specific environmental energies and survive and reproduce. In this way environmental energies direct the adaptive development of individual organisms and the adaptive evolution of species through the selection of reproductive phenotypes – hence genotypes.

Six laws of biodynamics that govern the behavior of all forms of life in reaction to their environments have been presented, with well-established scientific evidence demonstrating their validity. They are consistent with the laws of thermodynamics that govern the equilibrating behavior of enclosed, nonliving, reversible reaction systems.

The laws of biodynamics provide the biological sciences of genetics, cytology, embryology, biochemistry, physiology, psychology, and sociology, for the first time in their history, with a formulation of the basic natural processes involved in their special fields of investigation. These laws will clarify and facilitate the further development of secondary laws of the sciences of living behavior, as the laws of thermodynamics have advanced physics and chemistry.

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